

	FÉDÉRATION EUROPÉENNE DE LA MANUTENTION Product Group Industrial Trucks	FEM 4.007 draft April 2010
	Floors for Use of Industrial Trucks Very Narrow Aisles Trucks Requirements	

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1 Scope

This guideline specifies the requirements for dimensional regularity of finished floors inside of buildings used by guided VNA Industrial Trucks and other Industrial Trucks travelling with elevated loads (see EN 1726-2/ prEN ISO/DIS 3691-3) and/or operator positions inside very narrow aisles or in close proximity to racking in wide aisles.

2 List of references

This guideline incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this guideline only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 1726-2: Safety of industrial trucks - Self-propelled trucks up to and including 10000 kg capacity and tractors with a drawbar pull up to and including 20000 N - Part 2: Additional requirements for trucks with elevating operator position and trucks specifically designed to travel with elevated loads

prEN ISO/
DIS 3691-3: Industrial trucks - Safety requirements and verification - Part 3: Additional requirements for trucks with elevating operator position and trucks specifically designed to travel with elevated loads

3 Definitions

3.1 Finished floor

surface to be used by industrial trucks

3.2 Very narrow aisle (VNA)

aisle between racks for use of industrial trucks having minimum clearance of 90mm to the rack or the load

3.3 Section

any 2 m measuring length of a wheel track within the VNA

3.4 Transfer aisle

any area where the VNA industrial truck transfers between stacking areas

3.5 Elevational difference

difference in height between two points. The points can be fixed at prescribed distances or they can be moving pairs of points at prescribed distances apart

3.6 Change of elevational difference

the change in the elevational difference of two moving points, at a prescribed distance apart, in response to a movement of the two points over a prescribed distance.

3.7 Datum

a point used as a reference for levelling

3.8 Levelness

surface characteristics over a longer distance, typically 3 m, and to datum

3.9 Flatness

surface characteristics over a short distance, typically 300 mm

3.10 Waviness

repeating surface characteristics over a short distance

4 Requirements

The requirements for the functional components floor surface i.e. flat, level and smooth shall be such that the safe use of the VNA-Industrial-truck is not compromised.

Note: The following must be considered to ensure safe operation of VNA industrial trucks however specific criteria are not specified in this guideline

- floor surface with regard to traction performance
- floor mechanical resistance and durability
- criteria for the interface between drive wheel, load wheels and floor

4.1 Floors

4.1.1 General

Floors for Industrial Trucks covered by this guideline shall be flat and level.

With respect to non dimensional requirements, the floor quality shall meet the quality levels appropriate for use with industrial trucks.

4.1.2 Floor deflection and interruption

The finished floor shall not deflect plastically.

Shaft, channels, man-holes and similar interruptions of the floor surface shall be positioned with a minimum distance of 200 mm from wheel tracks and rack foot pads unless suitable load bearing devices are used.

4.2 Floor Tolerances

4.2.1 Limiting values of properties

The limiting values of properties shall not exceed those given in Annex A, Table A.1-A.3

4.2.2 Limiting values for general flatness in aisles (e.g. along the aisle) and in transfer aisles

The limiting values shall not exceed those given in Annex A, Table A.1 and A.2

4.2.3 Limiting values of Waviness Numbers Fx

Tolerances for floors used by Industrial Trucks covered by this guideline and their limiting values shall be manufactured, checked and measured by using Waviness Numbers. The values of Fx Waviness Numbers for all wheel tracks shall exceed the limiting values. See Annex A for calculation, measurement methods and limiting values Table A.3

4.2.4 Limiting values for levelness

All points on any 3 m grid shall be within +/- 15 mm of the datum, where the datum is across the whole of the truck operating area.

Annex A (normative)

A.1. FLOOR FLATNESS

A.1.1 Property Z and Z_{SLOPE}

Z is the dimension between the centres of truck load wheels (a, b) in m and Z_{SLOPE} is the permitted cross aisle slope between the centres of truck load wheels (a,b) in mm/m.

A.1.2 Property dZ

Property dZ is the elevational difference between the centres of truck load wheels (a, b) and dZ is determined as shown in figure A.1.

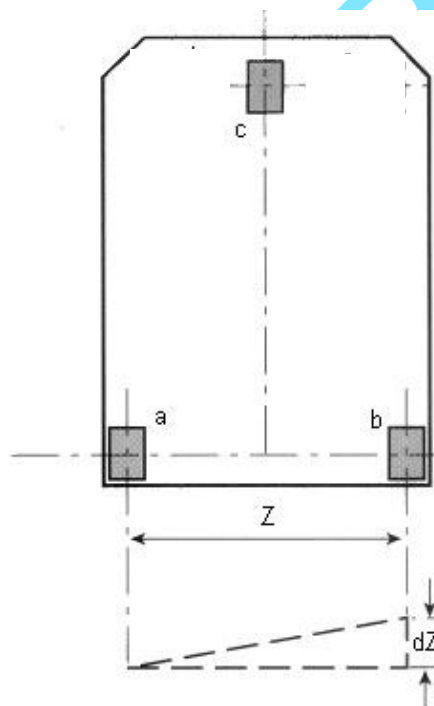


Figure A.1 Determination of dZ

A.1.3 Limiting values of properties

The values of properties shall not exceed the values given in Table A.1.

Top beam level (m)	Z_{SLOPE} (mm/m)	$dz = Z \times Z_{\text{slope}}$
15	1,0	$Z \times 1,0$ mm/m
10	1,5	$Z \times 1,5$ mm/m
up to 6	2,0	$Z \times 2,0$ mm/m

Note: For beam levels >6m, interpolation is required as illustrated in figure B.1

Table A.1 Limiting values of Z_{SLOPE}

A.1.4 Limiting values of a gap under a straight line for general flatness in stacking areas including very narrow aisles (e.g. along the aisle)

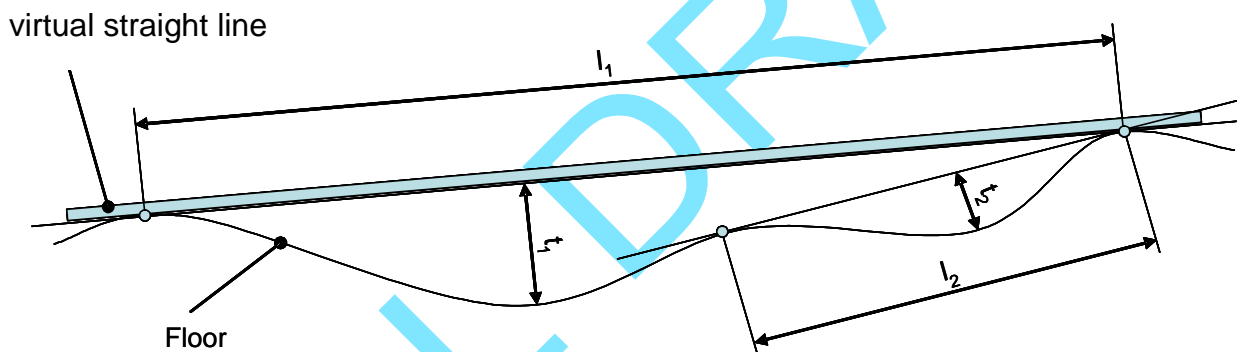


Figure A.2 Determination of gap under straight line

The values of a gap under a straight line shall not exceed the values given in Table A.2.

Distance between measurement l	1m	2m	3m	4m
Gap under straight line t	2mm	3mm	4mm	5mm

Table A.2 Limiting values of gap under straight line

A.1.5 Elevation difference d_i

d_i is the elevation difference between adjacent reading points.
 d_i is determined in mm as shown in figure A.3.

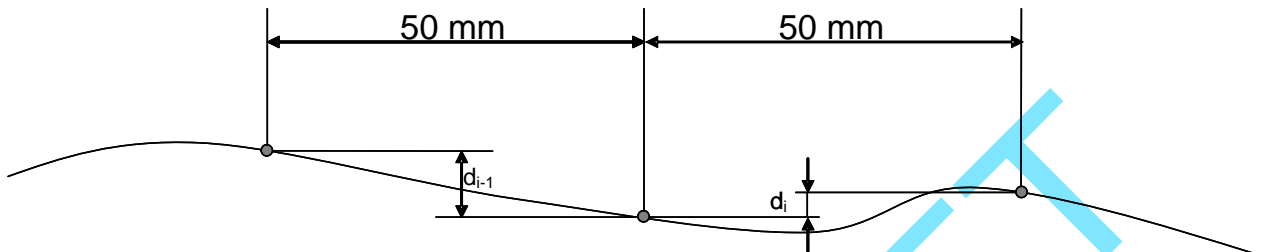


Figure A.3 Determination of d_i

A.1.6 Profile curvature q_i

q_i is the profile curvature between reading points. A positive q_i value will denote a trough, while a negative q_i value will denote a crest.
 q_i is determined in mm as follows:

$$q_i = d_i - d_{i-1}$$

A.1.7 Waviness Number F_x

F_x values estimate the floor's characteristic waviness, especially those of the wheel tracks. The F_x value of a wheel track is determined as follows:

A.1.7.1 Measurement

Measurement starts at first upright. Divide the aisle along the track into sections of 2 m. Within these sections, subdivide each line of wheel track into 50 mm long intervals. This results in 40 intervals in each section. The points marking the ends of these intervals are the 40 reading points. For each wheel track, measure and record in sequence the difference in elevation d_i (in mm) between adjacent reading points along the wheel track (see figure A.1). This results to 39 d_i values.

Measurement device shall meet the requirements and tolerances as described in figure A.4.

Other measurement methods are possible only if the results are demonstrably identical.

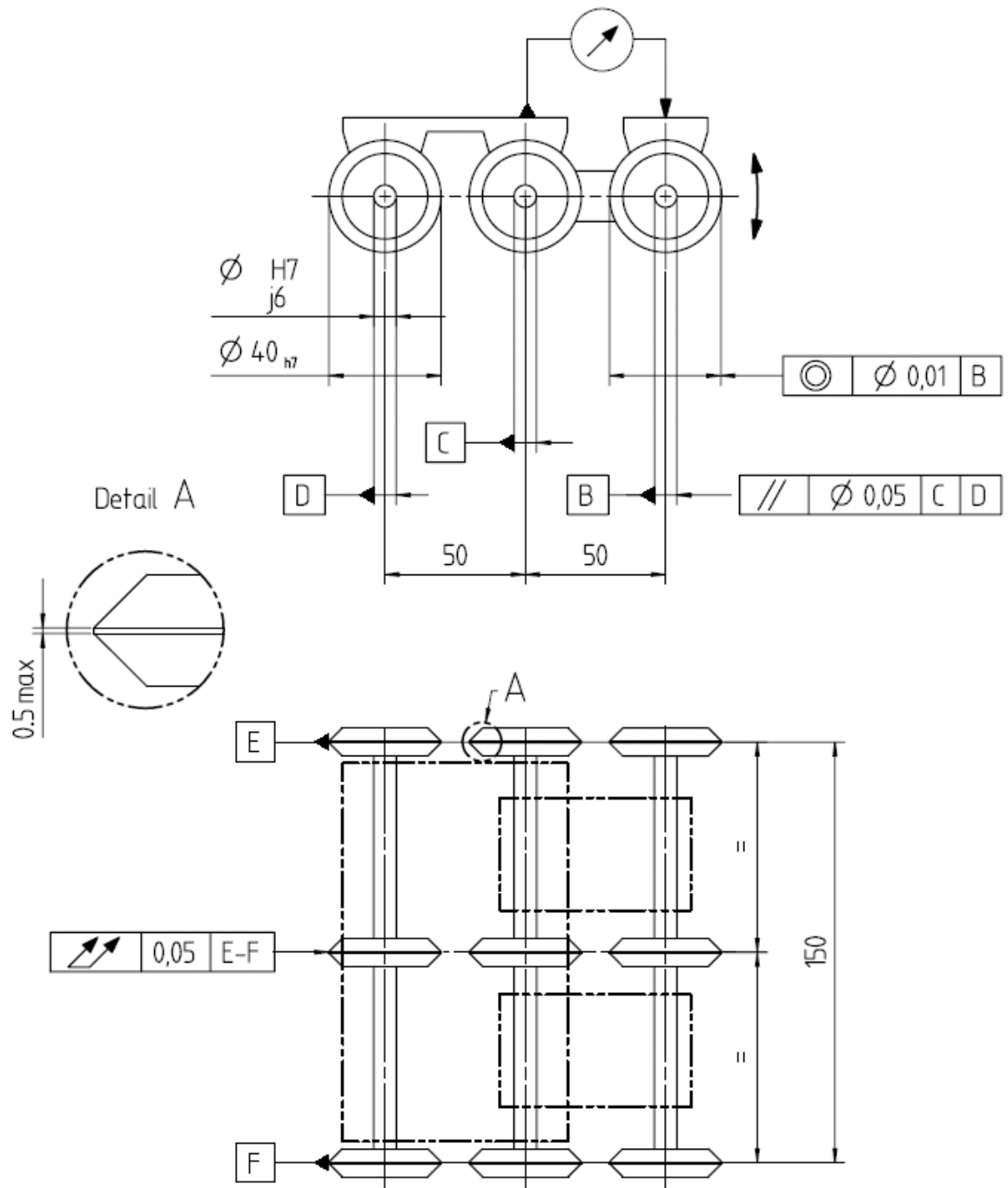


Figure A.4

Recommended layout for the measurement device of elevation difference d_i . The named tolerances are valid for all axles and rolls. Rolls made of steel.

A.1.7.2 Calculation - profile curvature

Calculate the profile curvatures, q_i , between all reading points as follows:

$$q_i = d_i - d_{i-1}$$

This results in 38 q_i values.

Annotation: These q_i values do not represent a difference in height any longer. They should be interpreted as a curvature – see A.1.6.

A.1.7.3 Calculation - arithmetic mean \bar{q}_i

Add all 38 q_i values as follows:

$$\sum_{i=2}^{39} q_i = q_2 + q_3 + q_4 + \dots + q_{39}$$

Divide this sum by 38 to obtain the mean value of the q_i values as follows:

$$\bar{q}_i = \frac{\sum_{i=2}^{39} q_i}{38}$$

A.1.7.4 Calculation - standard deviation S_q

Calculate the variance V_q of the q_i values as follows:

$$V_q = \frac{\sum_{i=2}^{39} q_i^2 - \bar{q}_i \sum_{i=2}^{39} q_i}{37}$$

Take the square root of the variance, V_q , to obtain the standard deviation, S_q , of the q_i values as follows:

$$S_q = \sqrt{V_q}$$

A.1.7.5 Calculation - Fx Waviness Number

Estimate the Fx Waviness Number for each wheel track as follows:

$$Fx = \frac{115,8454 \text{ mm}}{(3 \cdot S_q + |\bar{q}_i|)}$$

Note: The factor of 115,8454 mm represents a calibration factor.

1.7.6 Calculation – Fx,avg Waviness Number for continuous measurement method

It is possible to achieve an improved repeat accuracy by means of a continuous measurement along the aisle. If such a continuous measurement is chosen, the following requirements apply:

The measurement as described above is conducted in steps, 2 mm apart from each other. Over a distance of 50 mm, this procedure provides $n = 25$ different sets of reading points as described in A. 1.7.1, resulting in 25 $F_{x,n}$ results according to A. 1.7.5. The final value $F_{x,avg}$ is calculated by averaging these 25 $F_{x,n}$ values.

$$F_{x,avg} = \frac{\sum_{n=1}^{25} F_{x,n}}{25}$$

A.1.7.7 Calculation - Calculation Sheet

A sample sheet for conduction of the calculation described above is available on the FEM Website, www.fem-eur.com, product group "Industrial Trucks".

A.1.8 Limiting values of Waviness Numbers Fx or Fx,avg

The values of Fx or Fx,avg Waviness Numbers for all wheel tracks and all 2 m sections shall exceed the values given in Table A.3.

Top beam level (m)	Fx or Fx,avg
15	525
10	400
up to 6	300
Note: For beam levels >6m, interpolation is required as illustrated in figure B.3	

Table A.3 Limiting values of Fx or Fx,avg

Annex B (informative) (for the user)

B.1. EXAMPLE

B.1.1 Calculation

Parameters:

Top beam level = 8 m

Track width $Z = 1,5$ m

Requirements:

A.1.3 Table A.1: $Z_{SLOPE} = 1,75$ mm/m and $dZ = 2,625$ mm

A.1.4 Table A.2: Gap below requirement for all distances listed in the table

A.1.8 Table A.3: $F_x \geq 350$

B.1.2 Graph

Figures B.1 to B.3 illustrate the results of A.1.3, Table A.1 and A.1.4, Table A.2 and A.1.8, Table A.3 for above calculation example.

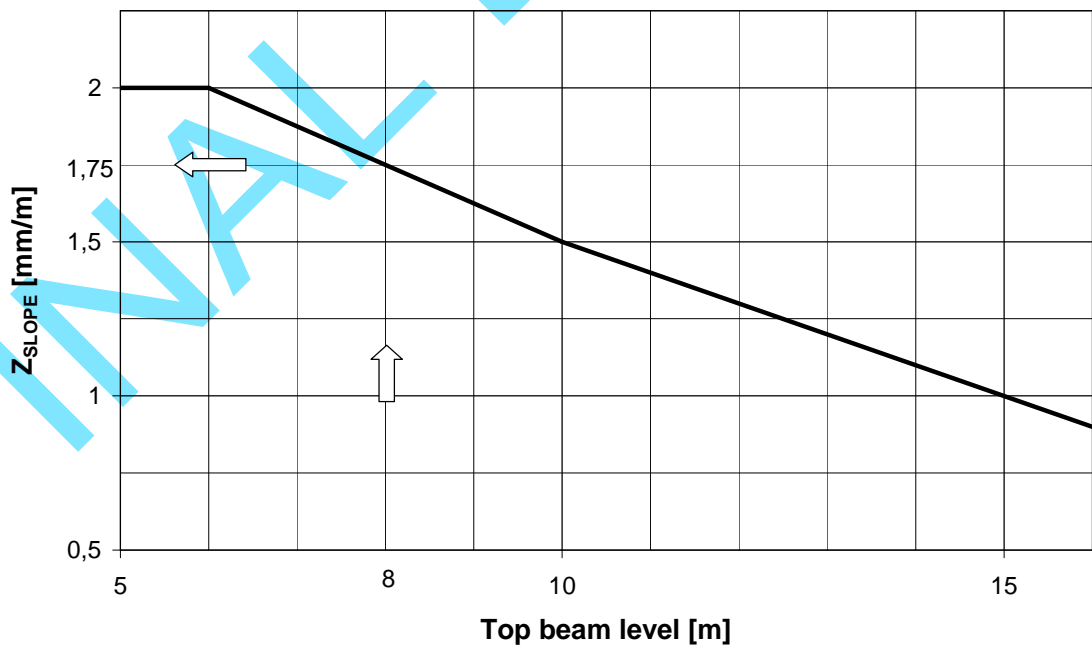


Figure B.1 Illustration for example - Z_{SLOPE}

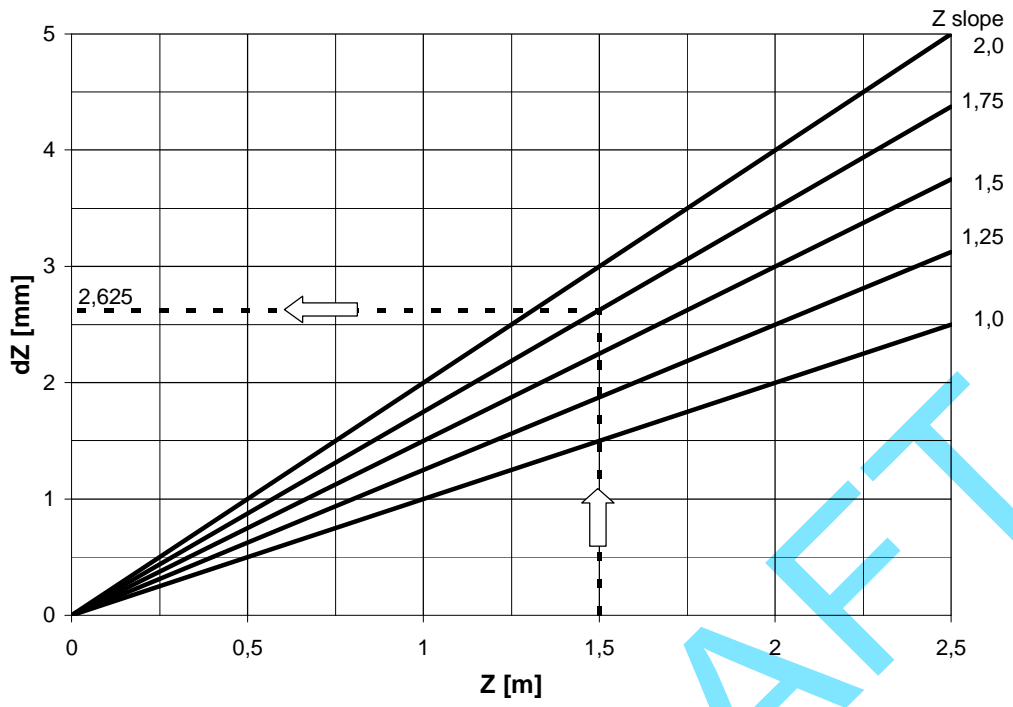


Figure B.2 Illustration for example – dZ

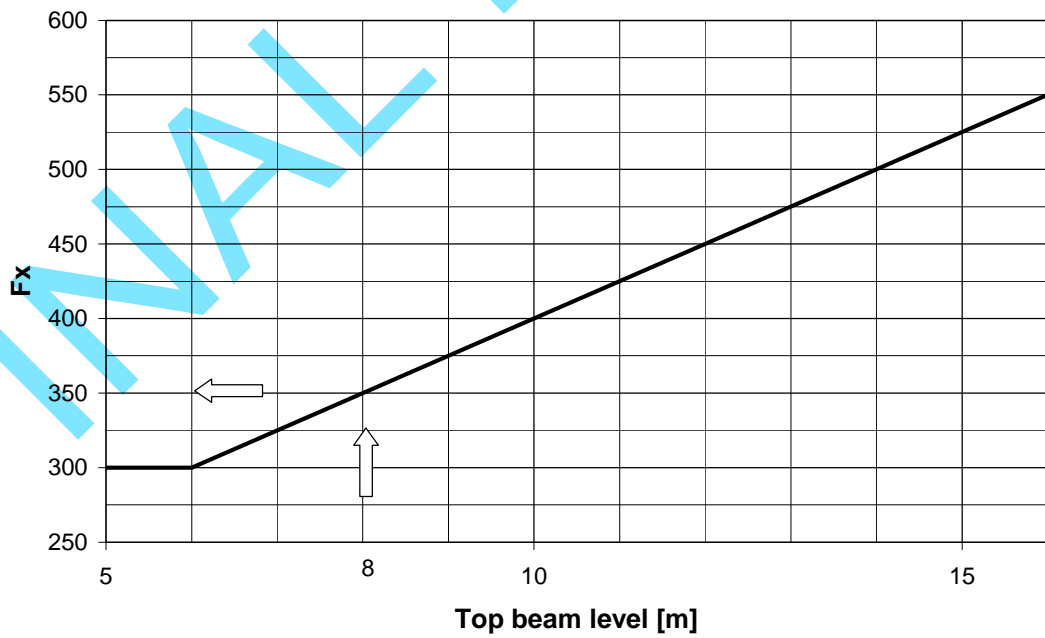


Figure B.3 Illustration for example - Fx

B.2. THE MAIN PRINCIPLE FOR THE MEASUREMENT OF THE CURVATURE OF A PROFILE

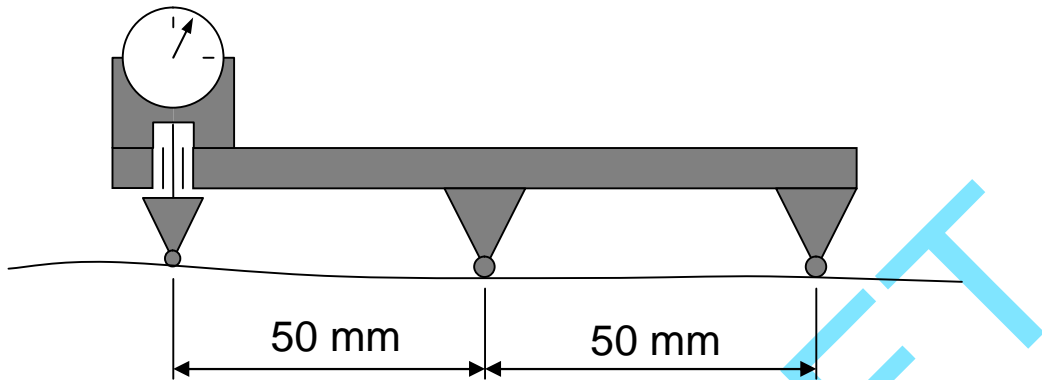


Figure B.3 The main principle for the measurement of the curvature of a profile

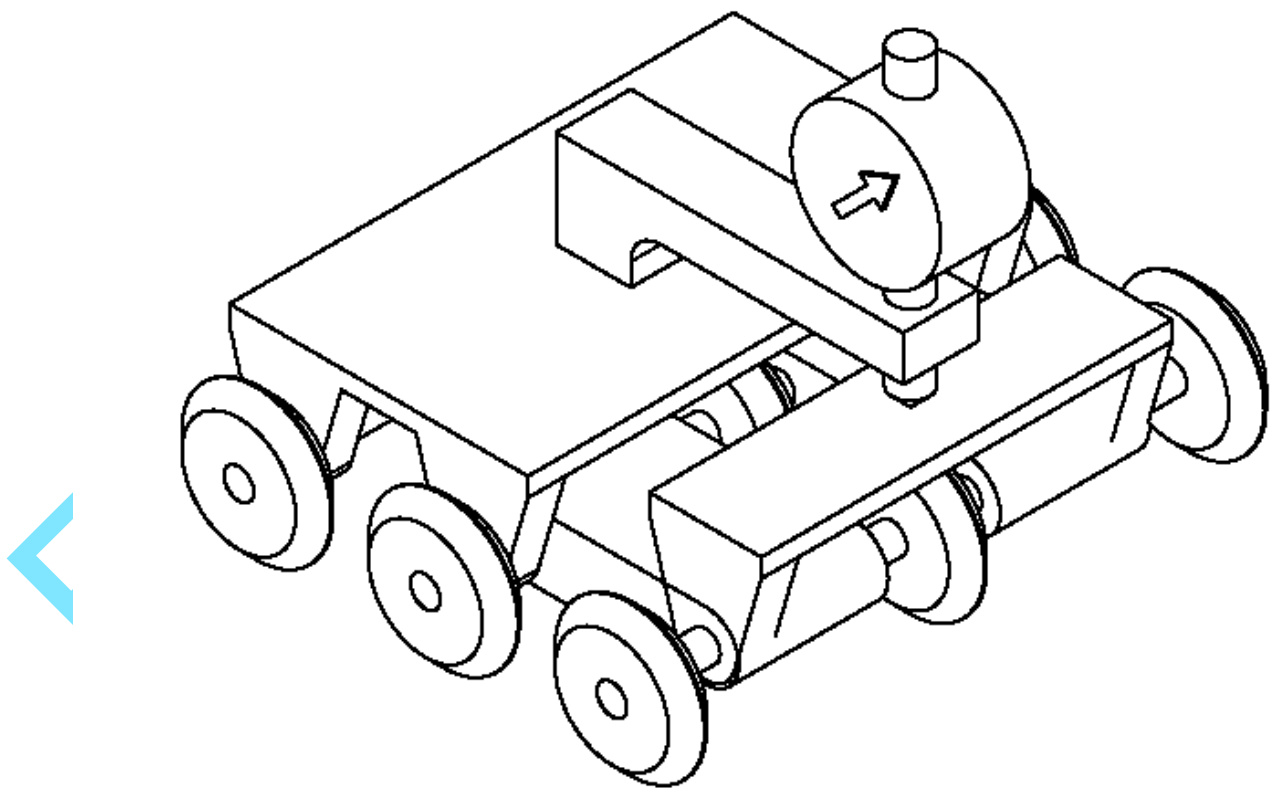


Figure B.4 The main principle for a simple measurement device (Curvature gauge)